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(71) Applicant *(for all designated States except US)*: INNAS FREE PISTON B.V. [NL/NL]; Nikkelstraat 15, NL-4823 AE Breda (NL).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: ACHTEN, Peter, Augustinus, Johannes [NL/NL]; Fazantlaan 3A, NL-5613 CA Eindhoven (NL).

(74) Agent: VAN BREDA, Jacques; Octrooibureau Los en Stigter B.V., Weteringschans 96, NL-1017 XS Amsterdam (NL).

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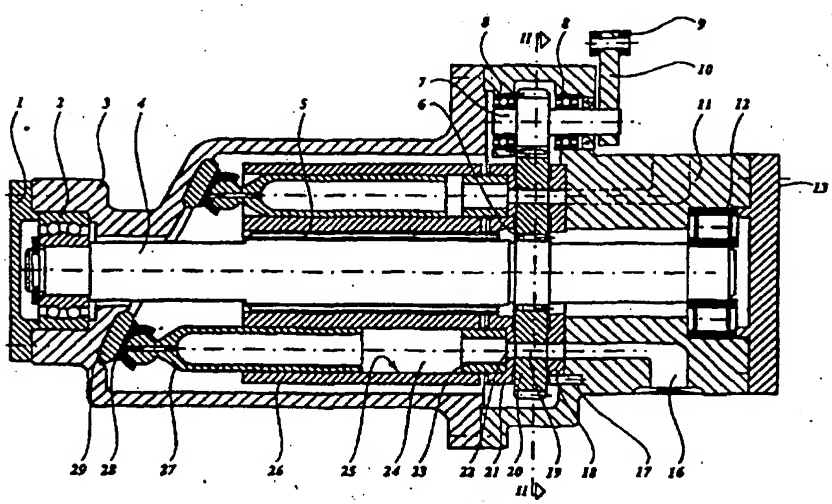
(54) Title: PRESSURE TRANSFORMER



(57) Abstract

The invention relates to a pressure transformer for the conversion of a hydraulic power from a first fluid flow having a first pressure into the hydraulic power of a second fluid flow having a second pressure. In the housing (3) a rotor (26) is mounted, able to rotate around a rotation shaft (4) due to the effect of the pressure differences between the three pipe connections (16). Around the rotation shaft chambers (24) are distributed comprising displacement means (27, 29) such as pistons (27) which, when the rotor (26) in the housing (3) rotates, vary the volume in the chambers (24) between a minimum and a maximum value, and channels (19, 22) provided with valves (20, 21) activated by the rotation of the rotor (26) and connecting each chamber (24) alternately with the first, the second and the third pipe connection (16).

PRESSURE TRANSFORMER

The invention relates to an appliance in accordance with the preamble of claim 1.

Such an appliance is known from the handbook "Hydrostatische Antriebe mit Sekundärregelung" von Mannesmann Rexroth GmbH, pp. 143-146.

The disadvantage of the known pressure transformer is that the costs involved are high, due to the fact that for a fluid flow of a certain volume and a certain pressure both a pump and a motor have to be used, at least one of which has to be adjustable and both of which have to be suitable for the maximum pressure developing and which have an allowable number of revolutions and stroke volume such as to be able to cope with the entire liquid flow.

Another disadvantage is that the known pressure transformer is provided with two rotors each having a set of chambers and each provided with valves which are activated by the rotor. Due to this double arrangement, the flow loss in the known transformers is relatively great and the leakage and expansion losses are twice the normal value, which is detrimental to the efficiency, realizing for instance, only about 70%.

The objective of the invention is to remove said disadvantages, and to this end the valves are designed such that when the rotor rotates, each chamber connects alternately with the first, the second and the third pipe connection.

This means that the pressure transformer can be more compact so that one single group of chambers arranged around the rotation shaft suffices, thereby lowering the costs and increasing the efficiency of the appliance to about 85%.

FR 1303925 discloses an appliance in which chambers constituting part of a rotor and located around a rotation shaft, are alternately connected with three pipe connections. This appliance is a pump in which the rotor is driven via a shaft and in which the fluid is drawn in via one or two of the three pipe connections and is pumped

to two or one pipe connection respectively. The difference between a pump and a pressure transformer is that with a pump mechanical energy is supplied to the shaft and rotor, and the energy is subsequently transferred to the fluid, whereas with a pressure transformer, the rotor is used for the transformation of hydraulic energy of the one form into hydraulic energy of another form.

In accordance with an embodiment of the pressure transformer according to the invention, the valves are slide valves activated by the rotor, having at the one side at least three channels which are distributed around the rotation shaft and which terminate in a diaphragm between the rotor and the housing, each being connected with a pipe connection, while each of the channels terminating at the other side of the diaphragm is connected with a chamber, and the diaphragm is provided with sealing means. This is a simple means for obtaining the rotation-dependent changing connection between the chambers and the three pipe connections.

In accordance with another aspect of the invention, adjusting means are provided for adjusting the rotation position of the displacement means which confer on the volume of a chamber a minimum or maximum value with respect to an opening position of the valves via which a particular chamber makes contact with one of the pipe connections. This adjusting means affords a simple and quick way for adjusting the pressure ratio between the different pipe connections while this pressure ratio is more or less independent of the rotor's number of revolutions, and it is in fact the displacement of the fluid as a result of the rotation of the rotor which strives to achieve the set pressure ratio.

In accordance with a further improvement of the invention, the rotation position of the displacement means with respect to the housing is fixed and the opening position with respect to the housing is adjustable by means of the adjusting means. This embodiment permits the construction to be simple and affords a quickly reacting adjustment of the pressure ratios; this is partly due to

the fact that relatively little force is required for the adjustment, as only the forces in the valves play a role and these forces are much weaker than the forces involved with, for instance, the displacement means. This vastly decreases the response time, something that is very important for many applications.

According to another improvement of the pressure transformer in accordance with the invention in which the adjusting means are directed by a control, the pipe connection to the hydraulic motor which is connected with the pressure transformer is provided with a pressure sensor connected with the control. In this way the control can immediately adjust the setting of the pressure transformer to match the motor load, thereby preventing that due to the altered pressure ratio the rotor rotates too quickly or stops, either of which would result in undesirable operating conditions.

Further the invention relates to an improvement of a pressure transformer in which the face plate has three channels between which a rib is provided, which rib during rotation of the rotor is able to seal a channel leading to a chamber. This absolute seal is necessary in order to avoid short circuiting between the different pipe connections, and usually the rotor is provided with an extra angle of rotation affording an absolute seal to limit leakage losses. As soon as after sealing the chamber comes into contact with the next channel, the pressure in the chamber suddenly changes because said channel has a completely different pressure level. This causes a loud noise, which is undesirable.

In order to avoid the above-mentioned disadvantages in the pressure transformer in accordance with the invention, the rib is dimensioned such that the chamber is completely sealed over a rotor rotation of not more than 2°. The dimensions of the ribs are preferably such that a rotation of about 1° seals the openings.

This achieves that during a short period of time the chamber is sealed, while rotation of the rotor causes a change of volume in the chamber. The change of volume is

always such that the pressure in the chamber, which was the same as in the compressed air connection just sealed, increases or decreases through the effect of the displacement means caused by the rotation, and to emulate the pressure prevailing in the compressed air connection to be opened. Choosing the proper width of the rib in accordance with the invention achieves that the pressure in the chamber is about the same as the pressure in the compressed air connection to be opened, greatly decreasing the noise nuisance.

According to a further improvement the pressure transformer in accordance with the invention is assembled combining a hydraulic motor and preferably a linear cylinder. This makes that the pipes between the pressure transformer and the motor are short, as a result of which there is less resilience in the oil column, and the hydraulic transient ensuing from the resilience, is prevented as much as possible. Since the hydraulic transient is detrimental to the quiet running of the rotor under the influence of the different oil pressures in the pipe connections, it is the combined assembly which achieves that the rotor runs more quietly in all load situations.

The invention also relates to a hydraulic system comprising a hydraulic aggregate for the generation of a fluid flow having a primary pressure, and wherein one or more hydraulically driven motors can be coupled with the fluid flow generated by the hydraulic aggregate at a secondary pressure.

Generally, in order to drive the motors in such a hydraulic system, which motors are suited to a lower pressure, use is made of a pressure reduction valve by means of which the primary pressure can be reduced to the secondary pressure. To do this, the fluid flow in the pressure reduction valve is throttled to the lower pressure losing an amount of energy proportional to the pressure difference.

In accordance with the invention, to prevent this disadvantage, a pressure transformer is provided between

the primary pressure and the secondary pressure. In this way a low-cost, no-loss pressure conversion is obtained.

The invention also relates to a hydraulic system comprising a hydraulic aggregate for the generation of a pressure difference between a low pressure and an operational pressure, wherein the low pressure is higher than a minimum pressure in the system.

In many hydraulic systems comprising, for instance, high-speed pumps the situation arises where, for example, the low pressure is maintained at 5 bar in order to prevent that cavitation occurs in the pumps, motors and in other components. The minimum pressure in the system is usually the atmospheric pressure, because one works with open tanks in which the fluid is collected. One problem in such systems is that the oil flow must be brought from the minimum pressure to the low pressure while incurring the least possible loss, as this oil flow concerns the entire oil flow. The known systems use separate pumps for this, the control of these pumps being complicated in order to restrict the losses.

It is the objective of the invention to improve these matters and to this end a pressure transformer is placed between the operational pressure and the low pressure. Due to the fact that the pressure transformer reacts immediately to fluid being drawn in by the pump, and the rotor, due to the reduction of the pressure, immediately reaches full revolutions as a result of the altered pressure ratios, no additional control is required, and a relatively low-cost, no-loss oil supply is achieved.

The invention will be elucidated in the specification below, describing a few examples of embodiments with reference to the drawing, in which:

Figure 1 show a schematic cross-section of a first embodiment of the pressure transformer in accordance with the invention,

Figure 2 shows the section II-II of the pressure transformer in accordance with Figure 1,

Figure 3 shows an alternative embodiment of the valves in accordance with Figure 2,

Figure 4 shows schematically the chamber volumes of the pressure transformer in accordance with Figure 1 with the high pressure and the effective pressure being more or less the same,

Figure 5 shows schematically the chamber volumes of the pressure transformer in accordance with Figure 1 with the high pressure being higher than the effective pressure,

Figure 6 shows schematically the chamber volumes of the pressure transformer in accordance with Figure 1 with the effective pressure and the low pressure being more or less the same,

Figure 7, 8 and 9 show schematically how the chambers are connected with the various compressed air connections in the situations shown in the Figs. 4, 5 and 6 respectively,

Figure 10 shows schematically the dimensions of the rib between the openings in the face plate in accordance with Figure 2,

Figure 11 shows a perspective view of a second embodiment of a pressure transformer in accordance with the invention,

Figure 12 shows a perspective view of the face plate of the pressure transformer in accordance with Figure 11,

Figure 13 shows a pipe diagram of the hydraulic system with a pressure transformer for the decrease of the pressure, and

Figure 14 shows a pipe diagram of the hydraulic system with a pressure transformer for the increase of the pressure.

Identical parts in the drawing are indicated as much as possible by corresponding reference numbers.

Figure 1 shows a first embodiment of a pressure transformer. A shaft 4 is supported by a bearing 2 and a bearing 12. The bearing 2 is fixed in a housing by means of a lid 1, the bearing 12 is fixed in a housing by means

of a lid 13. The housing 3 and the housing 11 are assembled in the known manner. The shaft 4 is provided with key toothing 5 with which a rotor 26 and a rotating sealing plate 21 are connected such as to be slidable in the direction of the shaft 4.

The rotor 26 is provided with nine cylinder bores 25 in which a sealing plug 23 is provided between the rotating sealing plate 21 and the rotor 26. Each bore 25 is provided with a piston 27 which has a piston shoe 28 set on a tilting plate 29. The piston 27 together with the bore 25 form a volume-variable pump chamber 24 connected by means of a channel 22 with an opening 19 in the face plate 20. The face plate 20 is provided with three openings 19, each connecting to an opening in a stationary sealing plate 18 fixed in the housing 11 and having a key peg 17 to ensure that each of the three openings in the stationary sealing plate 18 are positioned for a compressed air connection 16.

The face plate 20 is rotatably attached to the shaft 4 by means of a bearing 6. The circumference of the face plate 20 is provided with toothing engaging the toothing on a pinion shaft 7. The pinion shaft 7 is mounted in bearings 8 and can be rotated by means of a lever 10 which is movable by means of an adjusting mechanism 9. As can also be seen in Figure 2, the openings 19 are separated from each other by a rib 32, the first opening 19 being connected with a high-pressure channel 30, the second opening 19 to an effective-pressure channel 31 and the third opening 19 to a low-pressure channel 33.

Furthermore, the appliance incorporates all the known measures and construction details known from conventional hydraulic components such as pumps. This involves, for instance, the measures necessary for greasing and leak-off oil drainage. Sealing at the face plate 20 between the rotor 21 and the housing is also carried out in the usual manner.

In order to keep the rate of flow in the channels 30,31 and 33 as low as possible the area of the opening 19 at the side of the compressed air connection 16 is larger

than at the side of the pump chambers 24. This can be done in the manner shown in Figure 2 at 35, by narrowing the rib 32 at the side of the compressed air connection 16 plus the openings may optionally be widened.

Figure 3 shows an alternative embodiment of the face plate 20, in which instead of rotating the face plate 20, a movable rib 34 is used.

In the embodiment shown in Figure 1, the shaft 4 may be connected in the conventional manner with a sensor (not shown) measuring the direction and rate of the rotor's rotation, which data are processed in a control (not shown) and which controls the position of the face plate 20. The control of the pressure transformer functions such that the energy supplied to the rotor 26, that is to say the product of pressure and volume flow, corresponds with the energy taken from the rotor 26, possibly of a different pressure and volume flow, the difference in the volume flow being supplied or removed via a third, usually low pressure level. For this purpose the forces exerted on the rotor must be in balance, similarly, the mass balance of the fluid flows must be appropriate, both depending on the adjustment of the face plate.

Figures 4 to 9 show the various situations of employment of the pressure transformer with the relevant adjustments of the face plate 20 and the openings 19, where in Figures 4 and 7 an effective pressure P_N and a high pressure P_H are about the same, in Figures 5 and 8 the effective pressure P_N is lower than the high pressure P_H and in the Figures 6 and 9 the effective pressure P_N is about the same as a low pressure P_L. The two pump chambers 24 are indicated by A-I, while the line 29' indicates the influence of the tilting plate 29 on the volume of the pump chamber 24 and s a maximum stroke. The direction of movement ω indicates the movement of the pump chamber 24 along the tilting plate 29 when oil is supplied at the P_N side. One can see how with the same compressed air connection the volume of the pump chambers 24 can both increase and decrease, this can be regulated by adjusting

the face plate 20. This is shown, for instance, in Figure 11 at the high-pressure connection P_H, where with the direction of movement ω, the volume of the pump chamber 24 decreases at I to the minimum value at A, and subsequently increases.

In Figure 10 face plate 20 is drawn with the rib between the openings 19. As shown, the rib is larger than the diameter of the chamber opening 22, so that during a small portion of the rotation, being in total twice an angle α, the chamber is sealed. This angle α measures preferably 0.5 degrees in order to prevent hydraulic transient and cavitation. For special applications this angle α may be increased to about 1 degree.

In the first embodiment of the pressure transformer discussed above, pistons are movable in a cylinder and they move in the direction parallel to the rotation shaft. The invention can also be applied in other configurations of pistons and cylinders such as, for instance, where the piston's direction of movement forms an angle with or runs perpendicular to the rotation shaft. It is also possible to have the pistons and cylinders move eccentrically in relation to each other.

The face plate shown in the embodiment is provided with three openings and there are three compressed air connections. In special applications it is also possible to use the four or more compressed air connections, there will then also be more openings.

Instead of the face plate having three openings it is also possible to apply multiples of three, such as six openings. Instead of the face plate there are also other possibilities for sealing the channels to the pump chambers, such as, for instance, by means of electrically operated valves which are controlled by the rotation of the rotor.

In the respective embodiment the pistons are moved in and out of the pump chambers by means of a tilting plate. There are also embodiments of the pressure transformer, in parallel with the various embodiments existing of hydraulic pumps, in which the pistons are moved by

PRESSURE TRANSFORMER

The invention relates to an appliance in accordance with the preamble of claim 1.

Such an appliance is known from the handbook "Hydrostatische Antriebe mit Sekundärregelung" von Mannesmann Rexroth GmbH, pp. 143-146.

The disadvantage of the known pressure transformer is that the costs involved are high, due to the fact that for a fluid flow of a certain volume and a certain pressure both a pump and a motor have to be used, at least one of which has to be adjustable and both of which have to be suitable for the maximum pressure developing and which have an allowable number of revolutions and stroke volume such as to be able to cope with the entire liquid flow.

Another disadvantage is that the known pressure transformer is provided with two rotors each having a set of chambers and each provided with valves which are activated by the rotor. Due to this double arrangement, the flow loss in the known transformers is relatively great and the leakage and expansion losses are twice the normal value, which is detrimental to the efficiency, realizing for instance, only about 70%.

The objective of the invention is to remove said disadvantages, and to this end the valves are designed such that when the rotor rotates, each chamber connects alternately with the first, the second and the third pipe connection.

This means that the pressure transformer can be more compact so that one single group of chambers arranged around the rotation shaft suffices, thereby lowering the costs and increasing the efficiency of the appliance to about 85%.

FR 1303925 discloses an appliance in which chambers constituting part of a rotor and located around a rotation shaft, are alternately connected with three pipe connections. This appliance is a pump in which the rotor is driven via a shaft and in which the fluid is drawn in via one or two of the three pipe connections and is pumped

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(71) Applicant *(for all designated States except US)*: INNAS FREE PISTON B.V. [NL/NL]; Nikkelstraat 15, NL-4823 AE Breda (NL).

(72) Inventor; and
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(74) Agent: VAN BREDA, Jacques; Octrooibureau Los en Stigter B.V., Weteringschans 96, NL-1017 XS Amsterdam (NL).

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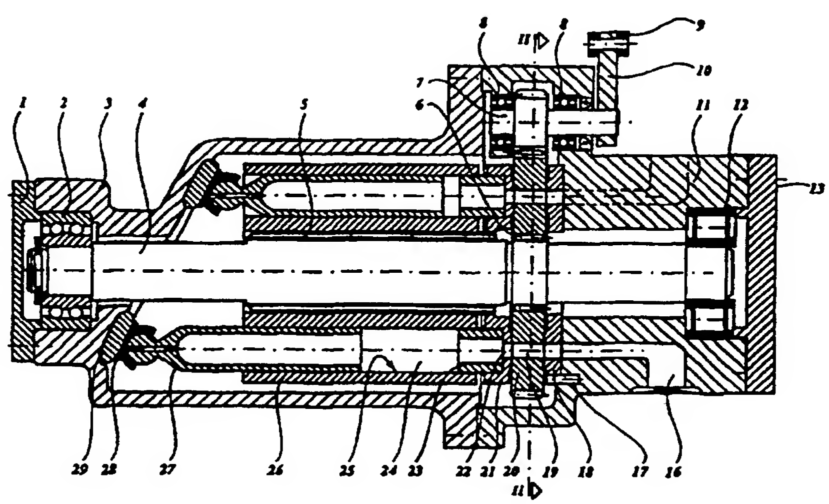

(57) Abstract

The invention relates to a pressure transformer for the conversion of a hydraulic power from a first fluid flow having a first pressure into the hydraulic power of a second fluid flow having a second pressure. In the housing (3) a rotor (26) is mounted, able to rotate around a rotation shaft (4) due to the effect of the pressure differences between the three pipe connections (16). Around the rotation shaft chambers (24) are distributed comprising displacement means (27, 29) such as pistons (27) which, when the rotor (26) in the housing (3) rotates, vary the volume in the chambers (24) between a minimum and a maximum value, and channels (19, 22) provided with valves (20, 21) activated by the rotation of the rotor (26) and connecting each chamber (24) alternately with the first, the second and the third pipe connection (16).

means of cam disks or by a forced movement between the housing and the rotor.

Apart from the appliances in which use is made of pistons and cylinders, the invention is also applicable when the volume of the pump chambers is varied by other means. In this regard one might consider pressure transformers with pump chambers similar to the chambers used in vanes pumps.

Figure 11 shows a pressure transformer 50 in which the pistons and the rotor containing the pump chambers rotate around different shafts so that the volume of the pump chambers varies when the rotor rotates. The rotation position of the face plate in relation to the housing can be adjusted with the aid of a shaft 54, thereby adjusting the pressure balance in the pressure transformer. The pressure transformer is provided with a high-pressure connection 51, where a fluid flow Q_H flows into the pressure transformer under a pressure P^H. A fluid flow Q_N leaves the pressure transformer under a pressure of P_N at an effective compressed air connection 52. The energy contents of both flows is the same, therefore if $P_H > P_N$ then $Q_H < Q_N$. The difference between the two fluid flows is supplied at the low-pressure connection 53 at a pressure of P_L and a fluid flow Q_L, so that $Q_L = Q_N - Q_H$. The pressure ratios are adjusted by rotation of the shaft 54. This shaft can be moved by means of a control system; it is also possible to maintain a fixed setting, so that the pressure ratio between P_H, P_N and P_L is fixed.

Figure 12 shows the kind of face plate 57 used in the pressure transformer 50 in Figure 11. The face plate is provided with three openings 55 separated by ribs 58 having a sealing edge 56. The face plate can be rotated around its axis by means of the shaft 54.

Figure 13 shows an application of a pressure transformer 61. By means of a pump 60, oil is brought up to a pressure p1, p1 being for instance, 400 bar. This pressure is particularly suitable for a hydraulic motor 62 which can be operated by means of a valve 66 and/or by means of the adjustment of the stroke volume which may be

available in the motor. Fluctuations in the oil pressure are absorbed by an accumulator 64. A linear drive 63 is suitable for a maximum pressure p2, p2 being for instance 180 bar. The linear drive 63 is operated by a valve 66 and an accumulator 65 is provided for the absorption of pressure fluctuations in the pressure p2. To lower the pressure p1 to p2, a pressure transformer 61 is applied, which pressure transformer may have a fixed setting, and may react without any further control to the fluid flow taken up by the linear cylinder. If the cylinder rate has to remain within certain limits, the pressure transformer 61 may be provided with a control.

Figure 14 shows another application of a pressure transformer 72. Herein a high-speed pump 70 has a suction pressure p4 and an outlet pressure p3. The suction pressure p4 always has to be higher than a certain value, for instance 5 bar, as otherwise cavitation will develop in the pump 70. The suction pressure p4 is provided by a pressure transformer 72 which ensures that the pressure p3 is converted into said suction pressure p4 with oil being supplied from a tank 73. A small accumulator 75 is placed between the pump 70 and the pressure transformer 72 to level out the pressure fluctuations. Several users 71 can be accommodated at the pressure side of the pump, while the pressure transformer 72 can also react to the changing volume flow if the pump has a controllable delivery. Between the pump 70 and the pressure transformer 72 an accumulator 74 is placed.

Another application is lifting a variable load by means of a hydraulic cylinder to which the energy is supplied under a constant high pressure and used under a varying pressure. By measuring this pressure and the rotor's 26 direction of rotation by means of a sensor, the setting of the face plate 20 may be calculated in regard to the desired movement. It is also possible after reversal of the direction of movement, to reconvert the energy released through the effect of the load into a higher pressure than the pressure prevailing in the hydraulic cylinder and to recover said energy for reuse.

In the embodiments shown here, the pressure transformer has always been presented as a separate unit. In connection with saving expenses and improving the adjustment performance and possible instability, the pressure transformer may be combined with a hydraulic motor. This improves the ability to accommodate load fluctuations, while at the same time the different hydraulic motors are, linearly of rotatingly, connected with a fluid network having a constant high pressure.

CLAIMS

1. A pressure transformer for the conversion of a hydraulic power from a first fluid flow (Q_H) having a first pressure (P_H) into the hydraulic power of a second fluid flow (Q_N) having a second pressure (P_N) by supplying or discharging a third fluid flow (Q_L) having a third pressure (P_L), comprising a housing(3,11) having at least three pipe connections (16; 51,52,53) for the connection of the fluid flows with the pressure transformer, in the housing a rotor (26) able to rotate around a rotation shaft due to the effect of the pressure differences between the pipe connections, chambers (24) distributed around the rotation shaft, displacement means (27,29) which when the rotor in the housing rotates, vary the volume in the chambers between a minimum and a maximum value and channels (19,22) provided with valves (20,21; 57) activated by the rotation of the rotor and alternately connecting each chamber with one of the pipe connections, **characterized** in that the valves (20,21; 57) are arranged such that on each rotation of the rotor (26) each chamber (24) alternately connects with the first (30;51), the second (31;52) and the third (33;53) pipe connection.

2. A pressure transformer in accordance with claim 1, **characterized** in that the valves are slide valves activated by the rotor, having at the one side at least three channels (19; 55) which are distributed around the rotation shaft and which terminate in a diaphragm between the rotor (26) and the housing (11), each being connected with a pipe connection (16,30,31,33; 51,52,53), while each of the channels (22) terminating at the other side (21) of the diaphragm is connected with a chamber (24), and the diaphragm is provided with sealing means (56).

3. A pressure transformer for the conversion of a hydraulic power from a first fluid flow (Q_H) having a first pressure (P_H) into the hydraulic power of a second fluid flow (Q_N) having a second pressure (P_N) by supplying or discharging a third fluid flow (Q_L) having a third pressure

(P_L), comprising a housing(3,11) having at least three pipe connections (16; 51,52,53) for the connection of the fluid flows with the pressure transformer, in the housing a rotor (26) able to rotate around a rotation shaft due to the effect of the pressure differences between the pipe connections, chambers (24) distributed around the rotation shaft, displacement means (27,29) which when the rotor in the housing rotates, vary the volume in the chambers between a minimum and a maximum value and channels (19,22) provided with valves (20,21; 57) activated by the rotation of the rotor and alternately connecting each chamber with one of the pipe connections and preferably arranged in accordance with claim 1 or 2, **characterized** in that adjusting means (7,9,10; 54) are provided for adjusting the rotation position of the displacement means (29) which confer on the volume of a chamber (24) a minimum or maximum value with respect to an opening position of the valves (20; 57) via which a particular chamber makes contact with one of the pipe connections (16,30,31,33; 51,52,53).

4. A pressure transformer in accordance with claim 3, **characterized** in that the rotation position of the displacement means (29) with respect to the housing (3) is fixed and the opening position with respect to the housing is adjustable by means of the adjusting means (7,9,10; 54).

5. A pressure transformer in accordance with any one of the preceding claims, **characterized** in that via one of the channels (19; 55) through a face plate (20; 57) the chambers (24) connect with one of the pipe connections (16; 51,52,53) and that the rotation position of the face plate (20; 57) in the housing (3) is adjustable.

6. A pressure transformer in accordance with claim 5, **characterized** in that the face plate (20; 57) in the housing (3) is rotatable with the aid of an adjustment means (7,9,10).

7. A pressure transformer in accordance with any one of the claims 3-6 in which the adjustment means (7,9,10) are directed by a control, **characterized** in that

the pipe connection (16,30,31,33; 51,52,53) to a hydraulic motor which is connected with the pressure transformer is provided with a pressure sensor connected with the control.

8. A pressure transformer in accordance with any one of the claims 5-7 in which the face plate (20; 57) has three channels (19; 55) between which a rib (32; 34; 58) is provided, which rib during rotation of the rotor (26) is able to seal a channel (22) leading to a chamber (24), **characterized** in that the rib (32; 34; 58) is dimensioned such that the chamber (24) is completely sealed over a rotor rotation of not more than 2°.

9. A pressure transformer in accordance with claim 8, **characterized** in that the rib (32; 34; 58) is dimensioned such that the chamber (24) is completely sealed over a rotor rotation of about 1°.

10. A pressure transformer in accordance with any of the preceding claims or a combination of these, **characterized** in that the pressure transformer is assembled in combination with a hydraulic motor.

11. A pressure transformer in accordance with claim 10, **characterized** in that the hydraulic motor is a linear cylinder.

12. A hydraulic system comprising a hydraulic aggregate (60) for the generation of a fluid flow having a primary pressure (p1), wherein one or more hydraulically driven motors (62) can be coupled with the fluid flow generated by the hydraulic aggregate at a primary pressure and wherein one or more hydraulically driven motors (63) can be coupled with the fluid flow generated by the hydraulic aggregate at a secondary pressure (p2), **characterized** in that a pressure transformer (61) is provided between the primary pressure (p1) and the secondary pressure (p2).

13. A hydraulic system comprising a hydraulic aggregate (70) for the generation of a pressure difference between a low pressure (p4) and an operational pressure (p3), wherein the low pressure is higher than a minimum pressure in the system, **characterized** in that a pressure

transformer (72) is provided between the operational pressure (p3) and the low pressure (p4).

AMENDED CLAIMS

[received by the International Bureau on 23 July 1997 (23.07.97); original claims 1-13 replaced by new claims 1-11 (3 pages)]

1. A pressure transformer for the conversion of a hydraulic power from a first fluid flow (Q_H) having a first pressure (P_H) into the hydraulic power of a second fluid flow (Q_N) having a second pressure (P_N) by supplying or discharging a third fluid flow (Q_L) having a third pressure (P_L), comprising a housing(3,11) having at least three pipe connections (16; 51,52,53) for the connection of the fluid flows with the pressure transformer, in the housing a rotor (26) able to rotate around a rotation shaft due to the effect of the pressure differences between the pipe connections, chambers (24) distributed around the rotation shaft, displacement means (27,29) which when the rotor in the housing rotates, vary the volume in the chambers between a minimum and a maximum value and channels (19,22) provided with valves (20,21; 57) activated by the rotation of the rotor and alternately connecting each chamber with one of the pipe connections, **characterized** in that adjusting means (7,9,10; 54) are provided for adjusting the rotation position of the displacement means (29) which confer on the volume of a chamber (24) a minimum or maximum value with respect to an opening position of the valves (20; 57) via which a particular chamber makes contact with one of the pipe connections (16,30,31,33; 51,52,53).

2. A pressure transformer in accordance with claim 1, **characterized** in that the rotation position of the displacement means (29) with respect to the housing (3) is fixed and the opening position with respect to the housing is adjustable by means of the adjusting means (7,9,10; 54).

3. A pressure transformer in accordance with any one of the preceding claims, **characterized** in that via one of at least three channels (19; 55) through a face plate (20; 57) the chambers (24) connect with one of the pipe connections (16; 51,52,53) and that the rotation position of the face plate (20; 57) in the housing (3) is

adjustable.

4. A pressure transformer in accordance with claim 3, **characterized** in that the face plate (20; 57) in the housing (3) is rotatable with the aid of the adjustment means (7,9,10).

5. A pressure transformer in accordance with any one of the claims 1-4 in which the adjustment means (7,9,10) are directed by a control, **characterized** in that the pipe connection (16,30,31,33; 51,52,53) to a hydraulic motor which is connected with the pressure transformer is provided with a pressure sensor connected with the control.

6. A pressure transformer in accordance with any one of the claims 3-5 in which the face plate (20; 57) has three channels (19; 55) between which a rib (32; 34; 58) is provided, which rib during rotation of the rotor (26) can seal a channel (22) leading to a chamber (24), **characterized** in that the rib (32; 34; 58) is dimensioned such that the chamber (24) is completely sealed over a rotor rotation of not more than 2°.

7. A pressure transformer in accordance with claim 6, **characterized** in that the rib (32; 34; 58) is dimensioned such that the chamber (24) is completely sealed over a rotor rotation of about 1°.

8. A pressure transformer in accordance with any of the preceding claims or a combination of these, whereby the second fluid flow drives a hydraulic motor on which the pressure transformer is fitted.

9. A pressure transformer in accordance with claim 8, **characterized** in that the hydraulic motor is a linear cylinder.

10. A hydraulic system comprising a hydraulic aggregate (60) for the generation of a fluid flow having a primary pressure (p1), wherein one or more hydraulically driven motors (62) can be coupled with the fluid flow generated by the hydraulic aggregate at a primary pressure and wherein one or more hydraulically driven motors (63) can be coupled with the fluid flow generated by the hydraulic aggregate at a secondary pressure (p2),

characterized in that a pressure transformer (61) is provided between the primary pressure (p1) and the secondary pressure (p2).

11. A hydraulic system comprising a hydraulic aggregate (70) for the generation of a pressure difference between a low pressure (p4) and an operational pressure (p3), wherein the low pressure is higher than a minimum pressure in the system, **characterized** in that a pressure transformer (72) is provided between the operational pressure (p3) and the low pressure (p4) for generating the low pressure.

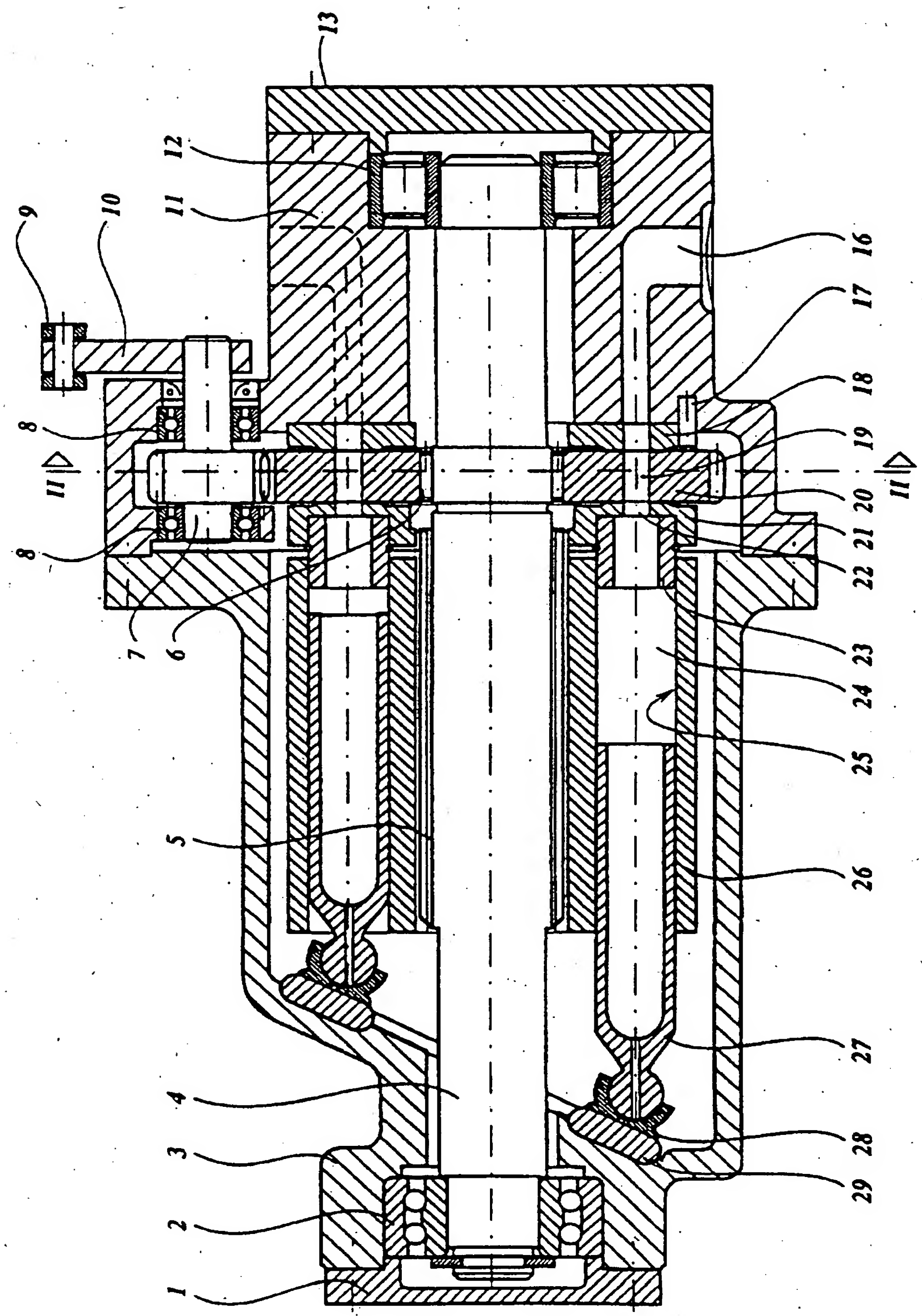
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Fig. 1

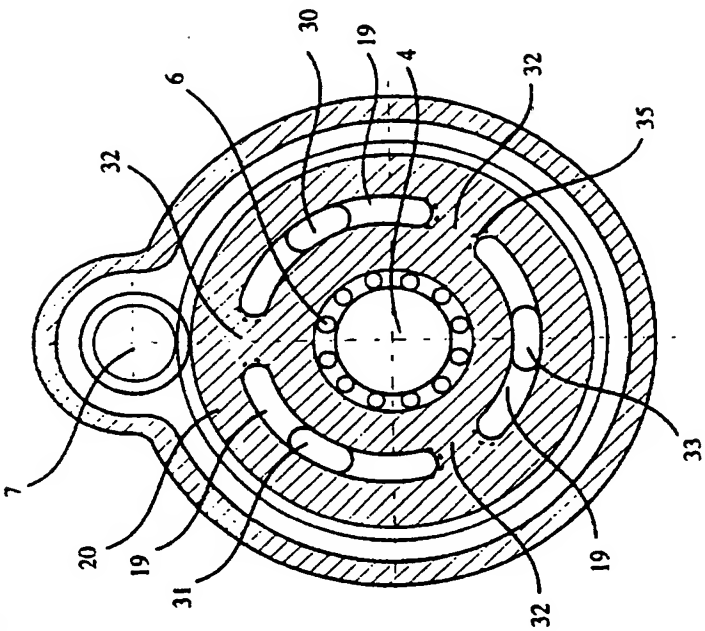

Fig. 2

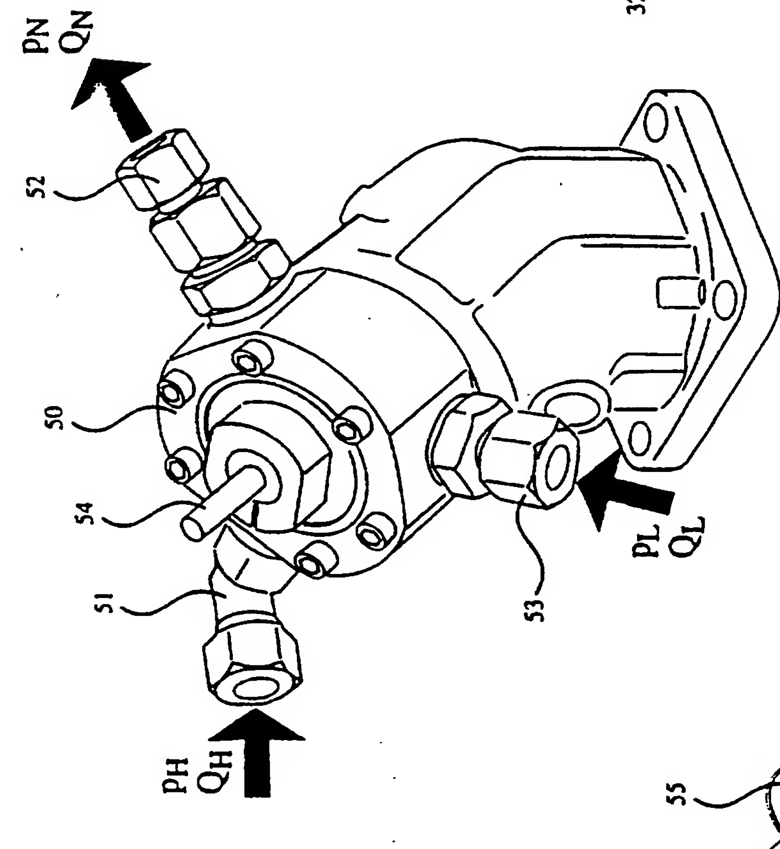

Fig. 11

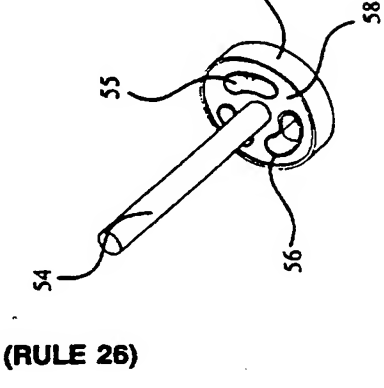

Fig. 12

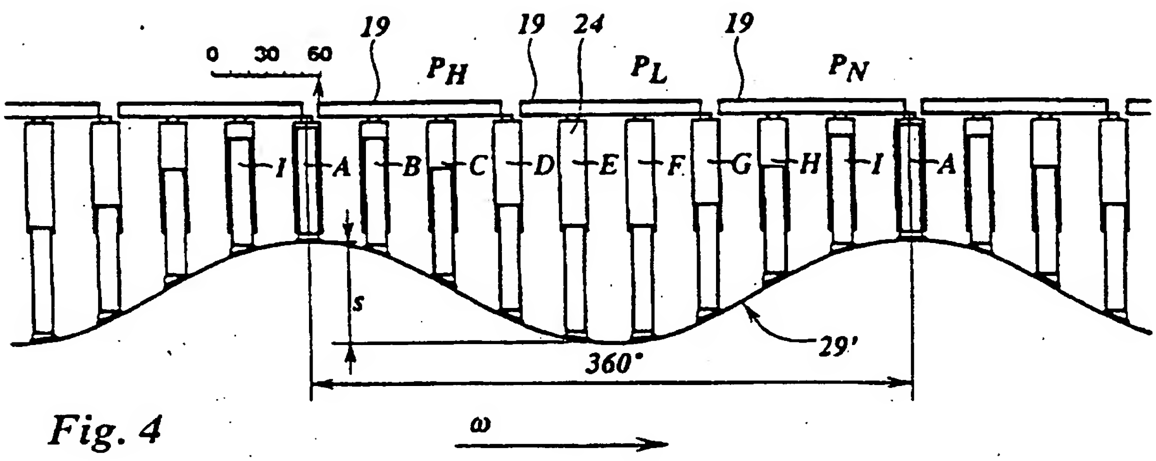

Fig. 4

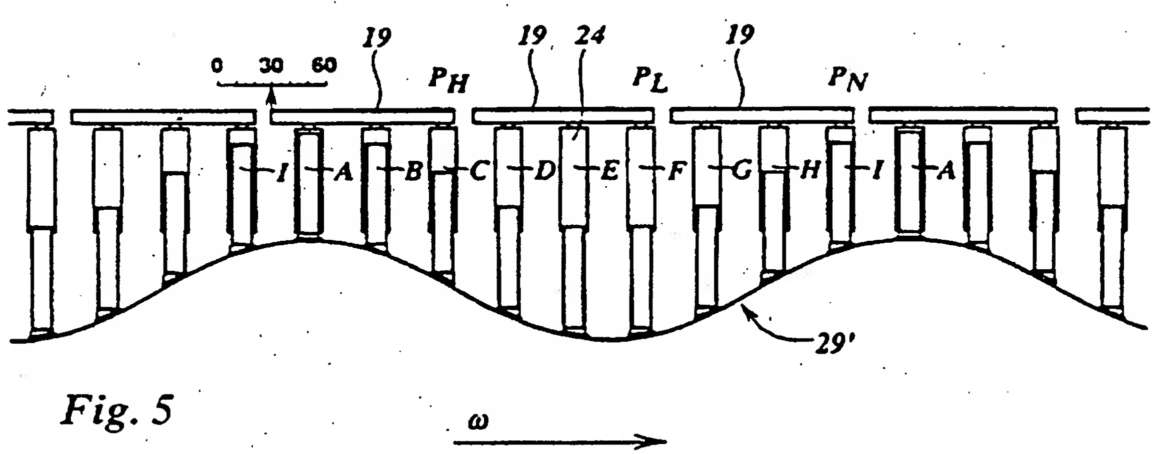

Fig. 5

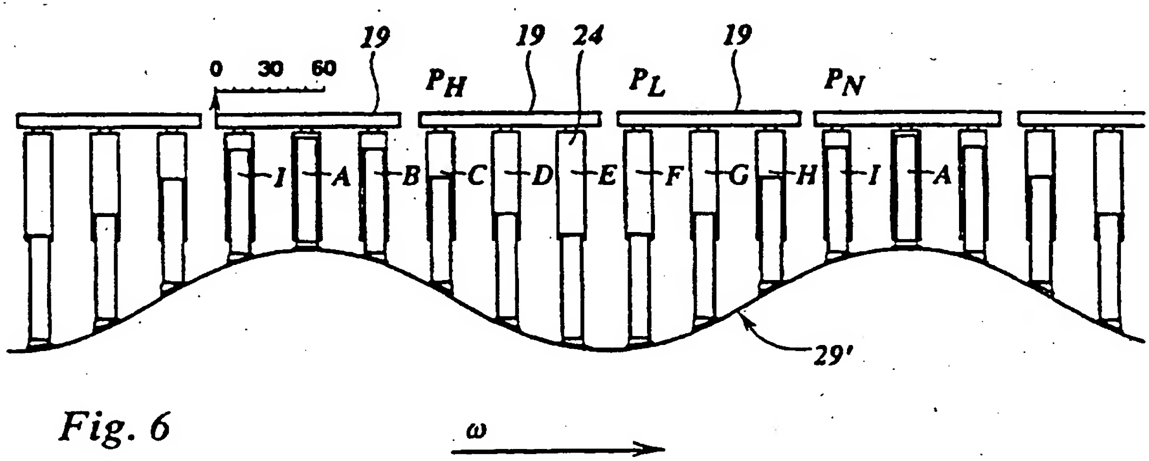

Fig. 6

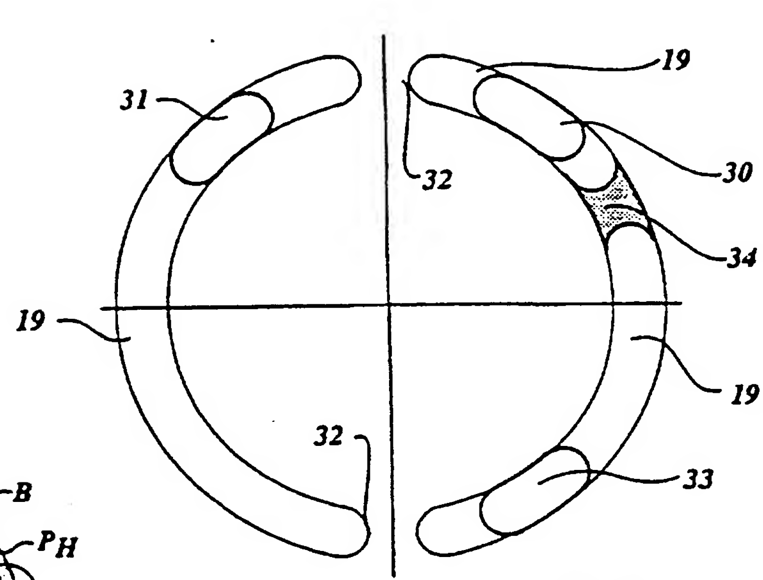

Fig. 3

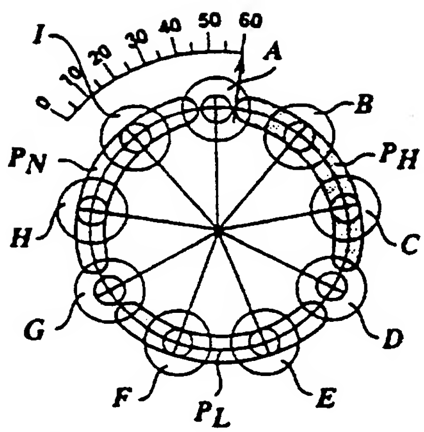

Fig. 7

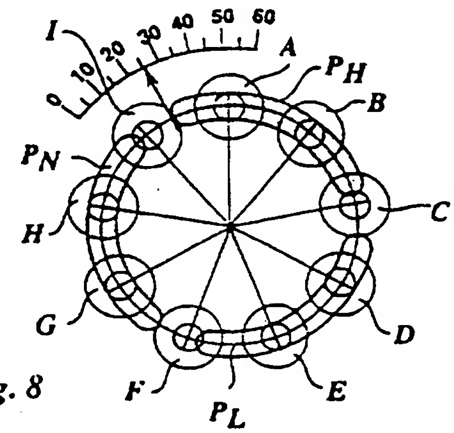

Fig. 8

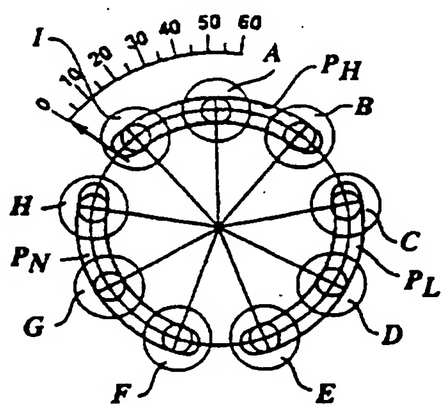

Fig. 9

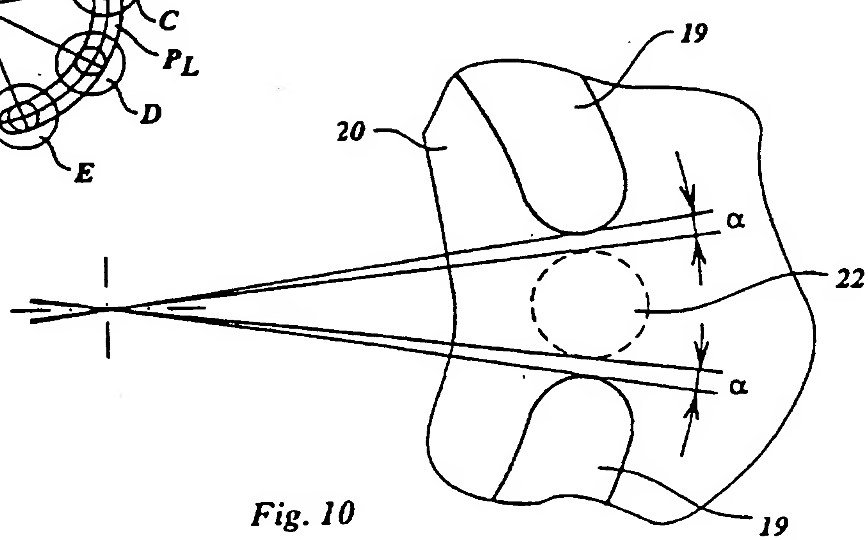

Fig. 10

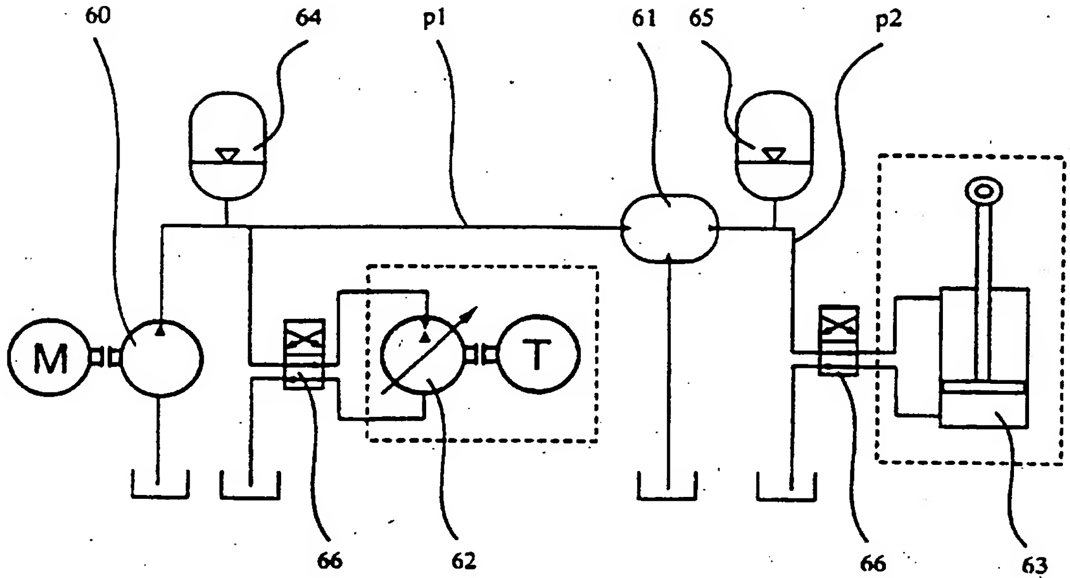

Fig. 13

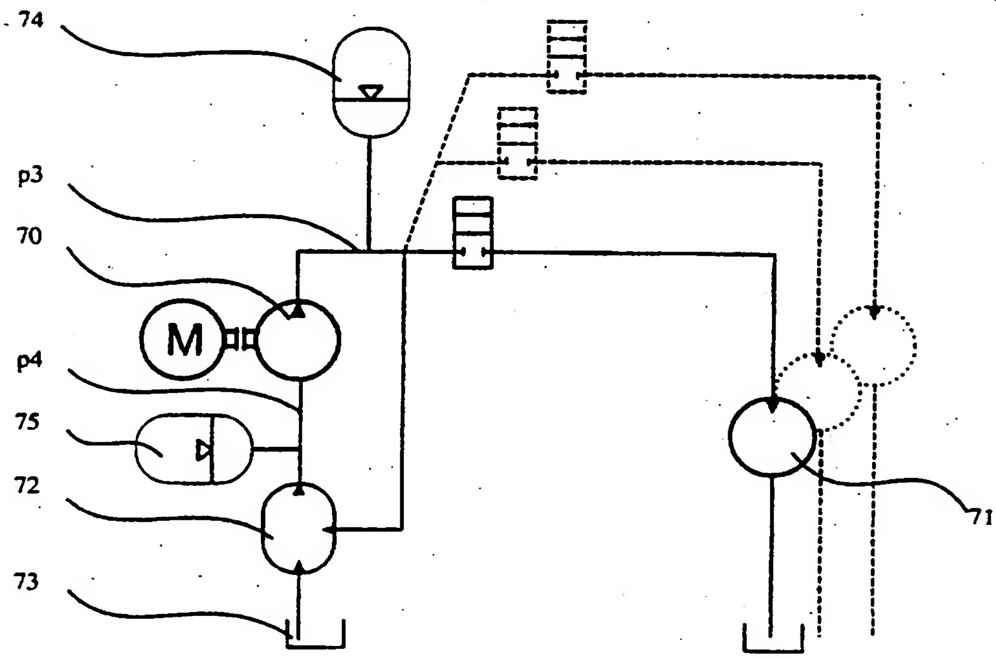

Fig. 14

INTERNATIONAL SEARCH REPORT

Inter. .onal Application No
PCT/NL 97/00084

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F04B1/30 F04B1/20 F01B3/00 F15B3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F04B F03C F01B F15B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 077 746 A (REYNOLDS) 7 March 1978 see the whole document ---	1,2
X	US 3 627 451 A (KOUNS HERBERT H) 14 December 1971 see the whole document ---	1,2
A	US 5 035 170 A (STROZE MARK S ET AL) 30 July 1991 see the whole document ---	3,5,6
A	FR 1 303 925 A (NATIONAL UNION ELECTRIC CORPORATION) 18 January 1963 cited in the application see the whole document ---	3,4,8,9
A	US 3 223 047 A (TOY) 14 December 1965 see the whole document ---	3-6
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

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Date of the actual completion of the international search	Date of mailing of the international search report
23 May 1997	16.06.97
Name and mailing address of the ISA	**Authorized officer**
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Von Arx, H

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 1 146 128 A (DAIMLER-BENZ AG) 6 November 1957 see the whole document	3-6
A	DE 12 00 071 B (BARNARD) 2 September 1965 see the whole document	1,2
A	DE 29 15 620 A (TRANSFORM VERSTAERKUNGSMASCH) 30 October 1980 see the whole document	10,11
A	US 2 933 897 A (TOUTANT) 26 April 1960 see the whole document	10-13
A	US 3 188 963 A (TYLER) 15 June 1965 see the whole document	10-13

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern. ial Application No
PCT/NL 97/00084

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4077746 A	07-03-78	NONE	
US 3627451 A	14-12-71	CA 918003 A	02-01-73
		DE 2115526 A	21-10-71
		FR 2092364 A	21-01-72
		GB 1340908 A	19-12-73
		NL 7100623 A,B	05-10-71
		SE 363523 B	21-01-74
US 5035170 A	30-07-91	NONE	
FR 1303925 A	18-01-63	NONE	
US 3223047 A	14-12-65	NONE	
FR 1146128 A	06-11-57	NONE	
DE 1200071 B		NONE	
DE 2915620 A	30-10-80	NONE	
US 2933897 A	26-04-60	NONE	
US 3188963 A	15-06-65	NONE	

to two or one pipe connection respectively. The difference between a pump and a pressure transformer is that with a pump mechanical energy is supplied to the shaft and rotor, and the energy is subsequently transferred to the fluid, whereas with a pressure transformer, the rotor is used for the transformation of hydraulic energy of the one form into hydraulic energy of another form.

In accordance with an embodiment of the pressure transformer according to the invention, the valves are slide valves activated by the rotor, having at the one side at least three channels which are distributed around the rotation shaft and which terminate in a diaphragm between the rotor and the housing, each being connected with a pipe connection, while each of the channels terminating at the other side of the diaphragm is connected with a chamber, and the diaphragm is provided with sealing means. This is a simple means for obtaining the rotation-dependent changing connection between the chambers and the three pipe connections.

In accordance with another aspect of the invention, adjusting means are provided for adjusting the rotation position of the displacement means which confer on the volume of a chamber a minimum or maximum value with respect to an opening position of the valves via which a particular chamber makes contact with one of the pipe connections. This adjusting means affords a simple and quick way for adjusting the pressure ratio between the different pipe connections while this pressure ratio is more or less independent of the rotor's number of revolutions, and it is in fact the displacement of the fluid as a result of the rotation of the rotor which strives to achieve the set pressure ratio.

In accordance with a further improvement of the invention, the rotation position of the displacement means with respect to the housing is fixed and the opening position with respect to the housing is adjustable by means of the adjusting means. This embodiment permits the construction to be simple and affords a quickly reacting adjustment of the pressure ratios; this is partly due to

the fact that relatively little force is required for the adjustment, as only the forces in the valves play a role and these forces are much weaker than the forces involved with, for instance, the displacement means. This vastly decreases the response time, something that is very important for many applications.

According to another improvement of the pressure transformer in accordance with the invention in which the adjusting means are directed by a control, the pipe connection to the hydraulic motor which is connected with the pressure transformer is provided with a pressure sensor connected with the control. In this way the control can immediately adjust the setting of the pressure transformer to match the motor load, thereby preventing that due to the altered pressure ratio the rotor rotates too quickly or stops, either of which would result in undesirable operating conditions.

Further the invention relates to an improvement of a pressure transformer in which the face plate has three channels between which a rib is provided, which rib during rotation of the rotor is able to seal a channel leading to a chamber. This absolute seal is necessary in order to avoid short circuiting between the different pipe connections, and usually the rotor is provided with an extra angle of rotation affording an absolute seal to limit leakage losses. As soon as after sealing the chamber comes into contact with the next channel, the pressure in the chamber suddenly changes because said channel has a completely different pressure level. This causes a loud noise, which is undesirable.

In order to avoid the above-mentioned disadvantages in the pressure transformer in accordance with the invention, the rib is dimensioned such that the chamber is completely sealed over a rotor rotation of not more than 2°. The dimensions of the ribs are preferably such that a rotation of about 1° seals the openings.

This achieves that during a short period of time the chamber is sealed, while rotation of the rotor causes a change of volume in the chamber. The change of volume is

always such that the pressure in the chamber, which was the same as in the compressed air connection just sealed, increases or decreases through the effect of the displacement means caused by the rotation, and to emulate the pressure prevailing in the compressed air connection to be opened. Choosing the proper width of the rib in accordance with the invention achieves that the pressure in the chamber is about the same as the pressure in the compressed air connection to be opened, greatly decreasing the noise nuisance.

According to a further improvement the pressure transformer in accordance with the invention is assembled combining a hydraulic motor and preferably a linear cylinder. This makes that the pipes between the pressure transformer and the motor are short, as a result of which there is less resilience in the oil column, and the hydraulic transient ensuing from the resilience, is prevented as much as possible. Since the hydraulic transient is detrimental to the quiet running of the rotor under the influence of the different oil pressures in the pipe connections, it is the combined assembly which achieves that the rotor runs more quietly in all load situations.

The invention also relates to a hydraulic system comprising a hydraulic aggregate for the generation of a fluid flow having a primary pressure, and wherein one or more hydraulically driven motors can be coupled with the fluid flow generated by the hydraulic aggregate at a secondary pressure.

Generally, in order to drive the motors in such a hydraulic system, which motors are suited to a lower pressure, use is made of a pressure reduction valve by means of which the primary pressure can be reduced to the secondary pressure. To do this, the fluid flow in the pressure reduction valve is throttled to the lower pressure losing an amount of energy proportional to the pressure difference.

In accordance with the invention, to prevent this disadvantage, a pressure transformer is provided between

the primary pressure and the secondary pressure. In this way a low-cost, no-loss pressure conversion is obtained.

The invention also relates to a hydraulic system comprising a hydraulic aggregate for the generation of a pressure difference between a low pressure and an operational pressure, wherein the low pressure is higher than a minimum pressure in the system.

In many hydraulic systems comprising, for instance, high-speed pumps the situation arises where, for example, the low pressure is maintained at 5 bar in order to prevent that cavitation occurs in the pumps, motors and in other components. The minimum pressure in the system is usually the atmospheric pressure, because one works with open tanks in which the fluid is collected. One problem in such systems is that the oil flow must be brought from the minimum pressure to the low pressure while incurring the least possible loss, as this oil flow concerns the entire oil flow. The known systems use separate pumps for this, the control of these pumps being complicated in order to restrict the losses.

It is the objective of the invention to improve these matters and to this end a pressure transformer is placed between the operational pressure and the low pressure. Due to the fact that the pressure transformer reacts immediately to fluid being drawn in by the pump, and the rotor, due to the reduction of the pressure, immediately reaches full revolutions as a result of the altered pressure ratios, no additional control is required, and a relatively low-cost, no-loss oil supply is achieved.

The invention will be elucidated in the specification below, describing a few examples of embodiments with reference to the drawing, in which:

Figure 1 show a schematic cross-section of a first embodiment of the pressure transformer in accordance with the invention,

Figure 2 shows the section II-II of the pressure transformer in accordance with Figure 1,

Figure 3 shows an alternative embodiment of the valves in accordance with Figure 2,

Figure 4 shows schematically the chamber volumes of the pressure transformer in accordance with Figure 1 with the high pressure and the effective pressure being more or less the same,

Figure 5 shows schematically the chamber volumes of the pressure transformer in accordance with Figure 1 with the high pressure being higher than the effective pressure,

Figure 6 shows schematically the chamber volumes of the pressure transformer in accordance with Figure 1 with the effective pressure and the low pressure being more or less the same,

Figure 7, 8 and 9 show schematically how the chambers are connected with the various compressed air connections in the situations shown in the Figs. 4, 5 and 6 respectively,

Figure 10 shows schematically the dimensions of the rib between the openings in the face plate in accordance with Figure 2,

Figure 11 shows a perspective view of a second embodiment of a pressure transformer in accordance with the invention,

Figure 12 shows a perspective view of the face plate of the pressure transformer in accordance with Figure 11,

Figure 13 shows a pipe diagram of the hydraulic system with a pressure transformer for the decrease of the pressure, and

Figure 14 shows a pipe diagram of the hydraulic system with a pressure transformer for the increase of the pressure.

Identical parts in the drawing are indicated as much as possible by corresponding reference numbers.

Figure 1 shows a first embodiment of a pressure transformer. A shaft 4 is supported by a bearing 2 and a bearing 12. The bearing 2 is fixed in a housing by means of a lid 1, the bearing 12 is fixed in a housing by means

of a lid 13. The housing 3 and the housing 11 are assembled in the known manner. The shaft 4 is provided with key toothing 5 with which a rotor 26 and a rotating sealing plate 21 are connected such as to be slidable in the direction of the shaft 4.

The rotor 26 is provided with nine cylinder bores 25 in which a sealing plug 23 is provided between the rotating sealing plate 21 and the rotor 26. Each bore 25 is provided with a piston 27 which has a piston shoe 28 set on a tilting plate 29. The piston 27 together with the bore 25 form a volume-variable pump chamber 24 connected by means of a channel 22 with an opening 19 in the face plate 20. The face plate 20 is provided with three openings 19, each connecting to an opening in a stationary sealing plate 18 fixed in the housing 11 and having a key peg 17 to ensure that each of the three openings in the stationary sealing plate 18 are positioned for a compressed air connection 16.

The face plate 20 is rotatably attached to the shaft 4 by means of a bearing 6. The circumference of the face plate 20 is provided with toothing engaging the toothing on a pinion shaft 7. The pinion shaft 7 is mounted in bearings 8 and can be rotated by means of a lever 10 which is movable by means of an adjusting mechanism 9. As can also be seen in Figure 2, the openings 19 are separated from each other by a rib 32, the first opening 19 being connected with a high-pressure channel 30, the second opening 19 to an effective-pressure channel 31 and the third opening 19 to a low-pressure channel 33.

Furthermore, the appliance incorporates all the known measures and construction details known from conventional hydraulic components such as pumps. This involves, for instance, the measures necessary for greasing and leak-off oil drainage. Sealing at the face plate 20 between the rotor 21 and the housing is also carried out in the usual manner.

In order to keep the rate of flow in the channels 30,31 and 33 as low as possible the area of the opening 19 at the side of the compressed air connection 16 is larger

than at the side of the pump chambers 24. This can be done in the manner shown in Figure 2 at 35, by narrowing the rib 32 at the side of the compressed air connection 16 plus the openings may optionally be widened.

Figure 3 shows an alternative embodiment of the face plate 20, in which instead of rotating the face plate 20, a movable rib 34 is used.

In the embodiment shown in Figure 1, the shaft 4 may be connected in the conventional manner with a sensor (not shown) measuring the direction and rate of the rotor's rotation, which data are processed in a control (not shown) and which controls the position of the face plate 20. The control of the pressure transformer functions such that the energy supplied to the rotor 26, that is to say the product of pressure and volume flow, corresponds with the energy taken from the rotor 26, possibly of a different pressure and volume flow, the difference in the volume flow being supplied or removed via a third, usually low pressure level. For this purpose the forces exerted on the rotor must be in balance, similarly, the mass balance of the fluid flows must be appropriate, both depending on the adjustment of the face plate.

Figures 4 to 9 show the various situations of employment of the pressure transformer with the relevant adjustments of the face plate 20 and the openings 19, where in Figures 4 and 7 an effective pressure P_N and a high pressure P_H are about the same, in Figures 5 and 8 the effective pressure P_N is lower than the high pressure P_H and in the Figures 6 and 9 the effective pressure P_N is about the same as a low pressure P_L. The two pump chambers 24 are indicated by A-I, while the line 29' indicates the influence of the tilting plate 29 on the volume of the pump chamber 24 and s a maximum stroke. The direction of movement ω indicates the movement of the pump chamber 24 along the tilting plate 29 when oil is supplied at the P_N side. One can see how with the same compressed air connection the volume of the pump chambers 24 can both increase and decrease, this can be regulated by adjusting

the face plate 20. This is shown, for instance, in Figure 11 at the high-pressure connection P_H, where with the direction of movement ω, the volume of the pump chamber 24 decreases at I to the minimum value at A, and subsequently increases.

In Figure 10 face plate 20 is drawn with the rib between the openings 19. As shown, the rib is larger than the diameter of the chamber opening 22, so that during a small portion of the rotation, being in total twice an angle α, the chamber is sealed. This angle α measures preferably 0.5 degrees in order to prevent hydraulic transient and cavitation. For special applications this angle α may be increased to about 1 degree.

In the first embodiment of the pressure transformer discussed above, pistons are movable in a cylinder and they move in the direction parallel to the rotation shaft. The invention can also be applied in other configurations of pistons and cylinders such as, for instance, where the piston's direction of movement forms an angle with or runs perpendicular to the rotation shaft. It is also possible to have the pistons and cylinders move eccentrically in relation to each other.

The face plate shown in the embodiment is provided with three openings and there are three compressed air connections. In special applications it is also possible to use the four or more compressed air connections, there will then also be more openings.

Instead of the face plate having three openings it is also possible to apply multiples of three, such as six openings. Instead of the face plate there are also other possibilities for sealing the channels to the pump chambers, such as, for instance, by means of electrically operated valves which are controlled by the rotation of the rotor.

In the respective embodiment the pistons are moved in and out of the pump chambers by means of a tilting plate. There are also embodiments of the pressure transformer, in parallel with the various embodiments existing of hydraulic pumps, in which the pistons are moved by

means of cam disks or by a forced movement between the housing and the rotor.

Apart from the appliances in which use is made of pistons and cylinders, the invention is also applicable when the volume of the pump chambers is varied by other means. In this regard one might consider pressure transformers with pump chambers similar to the chambers used in vanes pumps.

Figure 11 shows a pressure transformer 50 in which the pistons and the rotor containing the pump chambers rotate around different shafts so that the volume of the pump chambers varies when the rotor rotates. The rotation position of the face plate in relation to the housing can be adjusted with the aid of a shaft 54, thereby adjusting the pressure balance in the pressure transformer. The pressure transformer is provided with a high-pressure connection 51, where a fluid flow Q_H flows into the pressure transformer under a pressure P^H. A fluid flow Q_N leaves the pressure transformer under a pressure of P_N at an effective compressed air connection 52. The energy contents of both flows is the same, therefore if $P_H > P_N$ then $Q_H < Q_N$. The difference between the two fluid flows is supplied at the low-pressure connection 53 at a pressure of P_L and a fluid flow Q_L, so that $Q_L = Q_N - Q_H$. The pressure ratios are adjusted by rotation of the shaft 54. This shaft can be moved by means of a control system; it is also possible to maintain a fixed setting, so that the pressure ratio between P_H, P_N and P_L is fixed.

Figure 12 shows the kind of face plate 57 used in the pressure transformer 50 in Figure 11. The face plate is provided with three openings 55 separated by ribs 58 having a sealing edge 56. The face plate can be rotated around its axis by means of the shaft 54.

Figure 13 shows an application of a pressure transformer 61. By means of a pump 60, oil is brought up to a pressure p1, p1 being for instance, 400 bar. This pressure is particularly suitable for a hydraulic motor 62 which can be operated by means of a valve 66 and/or by means of the adjustment of the stroke volume which may be

available in the motor. Fluctuations in the oil pressure are absorbed by an accumulator 64. A linear drive 63 is suitable for a maximum pressure p2, p2 being for instance 180 bar. The linear drive 63 is operated by a valve 66 and an accumulator 65 is provided for the absorption of pressure fluctuations in the pressure p2. To lower the pressure p1 to p2, a pressure transformer 61 is applied, which pressure transformer may have a fixed setting, and may react without any further control to the fluid flow taken up by the linear cylinder. If the cylinder rate has to remain within certain limits, the pressure transformer 61 may be provided with a control.

Figure 14 shows another application of a pressure transformer 72. Herein a high-speed pump 70 has a suction pressure p4 and an outlet pressure p3. The suction pressure p4 always has to be higher than a certain value, for instance 5 bar, as otherwise cavitation will develop in the pump 70. The suction pressure p4 is provided by a pressure transformer 72 which ensures that the pressure p3 is converted into said suction pressure p4 with oil being supplied from a tank 73. A small accumulator 75 is placed between the pump 70 and the pressure transformer 72 to level out the pressure fluctuations. Several users 71 can be accommodated at the pressure side of the pump, while the pressure transformer 72 can also react to the changing volume flow if the pump has a controllable delivery. Between the pump 70 and the pressure transformer 72 an accumulator 74 is placed.

Another application is lifting a variable load by means of a hydraulic cylinder to which the energy is supplied under a constant high pressure and used under a varying pressure. By measuring this pressure and the rotor's 26 direction of rotation by means of a sensor, the setting of the face plate 20 may be calculated in regard to the desired movement. It is also possible after reversal of the direction of movement, to reconvert the energy released through the effect of the load into a higher pressure than the pressure prevailing in the hydraulic cylinder and to recover said energy for reuse.

In the embodiments shown here, the pressure transformer has always been presented as a separate unit. In connection with saving expenses and improving the adjustment performance and possible instability, the pressure transformer may be combined with a hydraulic motor. This improves the ability to accommodate load fluctuations, while at the same time the different hydraulic motors are, linearly of rotatingly, connected with a fluid network having a constant high pressure.

CLAIMS

1. A pressure transformer for the conversion of a hydraulic power from a first fluid flow (Q_H) having a first pressure (P_H) into the hydraulic power of a second fluid flow (Q_N) having a second pressure (P_N) by supplying or discharging a third fluid flow (Q_L) having a third pressure (P_L), comprising a housing(3,11) having at least three pipe connections (16; 51,52,53) for the connection of the fluid flows with the pressure transformer, in the housing a rotor (26) able to rotate around a rotation shaft due to the effect of the pressure differences between the pipe connections, chambers (24) distributed around the rotation shaft, displacement means (27,29) which when the rotor in the housing rotates, vary the volume in the chambers between a minimum and a maximum value and channels (19,22) provided with valves (20,21; 57) activated by the rotation of the rotor and alternately connecting each chamber with one of the pipe connections, **characterized** in that the valves (20,21; 57) are arranged such that on each rotation of the rotor (26) each chamber (24) alternately connects with the first (30;51), the second (31;52) and the third (33;53) pipe connection.

2. A pressure transformer in accordance with claim 1, **characterized** in that the valves are slide valves activated by the rotor, having at the one side at least three channels (19; 55) which are distributed around the rotation shaft and which terminate in a diaphragm between the rotor (26) and the housing (11), each being connected with a pipe connection (16,30,31,33; 51,52,53), while each of the channels (22) terminating at the other side (21) of the diaphragm is connected with a chamber (24), and the diaphragm is provided with sealing means (56).

3. A pressure transformer for the conversion of a hydraulic power from a first fluid flow (Q_H) having a first pressure (P_H) into the hydraulic power of a second fluid flow (Q_N) having a second pressure (P_N) by supplying or discharging a third fluid flow (Q_L) having a third pressure

(P_L), comprising a housing(3,11) having at least three pipe connections (16; 51,52,53) for the connection of the fluid flows with the pressure transformer, in the housing a rotor (26) able to rotate around a rotation shaft due to the effect of the pressure differences between the pipe connections, chambers (24) distributed around the rotation shaft, displacement means (27,29) which when the rotor in the housing rotates, vary the volume in the chambers between a minimum and a maximum value and channels (19,22) provided with valves (20,21; 57) activated by the rotation of the rotor and alternately connecting each chamber with one of the pipe connections and preferably arranged in accordance with claim 1 or 2, **characterized** in that adjusting means (7,9,10; 54) are provided for adjusting the rotation position of the displacement means (29) which confer on the volume of a chamber (24) a minimum or maximum value with respect to an opening position of the valves (20; 57) via which a particular chamber makes contact with one of the pipe connections (16,30,31,33; 51,52,53).

4. A pressure transformer in accordance with claim 3, **characterized** in that the rotation position of the displacement means (29) with respect to the housing (3) is fixed and the opening position with respect to the housing is adjustable by means of the adjusting means (7,9,10; 54).

5. A pressure transformer in accordance with any one of the preceding claims, **characterized** in that via one of the channels (19; 55) through a face plate (20; 57) the chambers (24) connect with one of the pipe connections (16; 51,52,53) and that the rotation position of the face plate (20; 57) in the housing (3) is adjustable.

6. A pressure transformer in accordance with claim 5, **characterized** in that the face plate (20; 57) in the housing (3) is rotatable with the aid of an adjustment means (7,9,10).

7. A pressure transformer in accordance with any one of the claims 3-6 in which the adjustment means (7,9,10) are directed by a control, **characterized** in that

the pipe connection (16,30,31,33; 51,52,53) to a hydraulic motor which is connected with the pressure transformer is provided with a pressure sensor connected with the control.

8. A pressure transformer in accordance with any one of the claims 5-7 in which the face plate (20; 57) has three channels (19; 55) between which a rib (32; 34; 58) is provided, which rib during rotation of the rotor (26) is able to seal a channel (22) leading to a chamber (24), **characterized** in that the rib (32; 34; 58) is dimensioned such that the chamber (24) is completely sealed over a rotor rotation of not more than 2°.

9. A pressure transformer in accordance with claim 8, **characterized** in that the rib (32; 34; 58) is dimensioned such that the chamber (24) is completely sealed over a rotor rotation of about 1°.

10. A pressure transformer in accordance with any of the preceding claims or a combination of these, **characterized** in that the pressure transformer is assembled in combination with a hydraulic motor.

11. A pressure transformer in accordance with claim 10, **characterized** in that the hydraulic motor is a linear cylinder.

12. A hydraulic system comprising a hydraulic aggregate (60) for the generation of a fluid flow having a primary pressure (p1), wherein one or more hydraulically driven motors (62) can be coupled with the fluid flow generated by the hydraulic aggregate at a primary pressure and wherein one or more hydraulically driven motors (63) can be coupled with the fluid flow generated by the hydraulic aggregate at a secondary pressure (p2), **characterized** in that a pressure transformer (61) is provided between the primary pressure (p1) and the secondary pressure (p2).

13. A hydraulic system comprising a hydraulic aggregate (70) for the generation of a pressure difference between a low pressure (p4) and an operational pressure (p3), wherein the low pressure is higher than a minimum pressure in the system, **characterized** in that a pressure

transformer (72) is provided between the operational pressure (p3) and the low pressure (p4).

AMENDED CLAIMS

[received by the International Bureau on 23 July 1997 (23.07.97); original claims 1-13 replaced by new claims 1-11 (3 pages)]

1. A pressure transformer for the conversion of a hydraulic power from a first fluid flow (Q_H) having a first pressure (P_H) into the hydraulic power of a second fluid flow (Q_N) having a second pressure (P_N) by supplying or discharging a third fluid flow (Q_L) having a third pressure (P_L), comprising a housing(3,11) having at least three pipe connections (16; 51,52,53) for the connection of the fluid flows with the pressure transformer, in the housing a rotor (26) able to rotate around a rotation shaft due to the effect of the pressure differences between the pipe connections, chambers (24) distributed around the rotation shaft, displacement means (27,29) which when the rotor in the housing rotates, vary the volume in the chambers between a minimum and a maximum value and channels (19,22) provided with valves (20,21; 57) activated by the rotation of the rotor and alternately connecting each chamber with one of the pipe connections, **characterized** in that adjusting means (7,9,10; 54) are provided for adjusting the rotation position of the displacement means (29) which confer on the volume of a chamber (24) a minimum or maximum value with respect to an opening position of the valves (20; 57) via which a particular chamber makes contact with one of the pipe connections (16,30,31,33; 51,52,53).

2. A pressure transformer in accordance with claim 1, **characterized** in that the rotation position of the displacement means (29) with respect to the housing (3) is fixed and the opening position with respect to the housing is adjustable by means of the adjusting means (7,9,10; 54).

3. A pressure transformer in accordance with any one of the preceding claims, **characterized** in that via one of at least three channels (19; 55) through a face plate (20; 57) the chambers (24) connect with one of the pipe connections (16; 51,52,53) and that the rotation position of the face plate (20; 57) in the housing (3) is

adjustable.

4. A pressure transformer in accordance with claim 3, **characterized** in that the face plate (20; 57) in the housing (3) is rotatable with the aid of the adjustment means (7,9,10).

5. A pressure transformer in accordance with any one of the claims 1-4 in which the adjustment means (7,9,10) are directed by a control, **characterized** in that the pipe connection (16,30,31,33; 51,52,53) to a hydraulic motor which is connected with the pressure transformer is provided with a pressure sensor connected with the control.

6. A pressure transformer in accordance with any one of the claims 3-5 in which the face plate (20; 57) has three channels (19; 55) between which a rib (32; 34; 58) is provided, which rib during rotation of the rotor (26) can seal a channel (22) leading to a chamber (24), **characterized** in that the rib (32; 34; 58) is dimensioned such that the chamber (24) is completely sealed over a rotor rotation of not more than 2°.

7. A pressure transformer in accordance with claim 6, **characterized** in that the rib (32; 34; 58) is dimensioned such that the chamber (24) is completely sealed over a rotor rotation of about 1°.

8. A pressure transformer in accordance with any of the preceding claims or a combination of these, whereby the second fluid flow drives a hydraulic motor on which the pressure transformer is fitted.

9. A pressure transformer in accordance with claim 8, **characterized** in that the hydraulic motor is a linear cylinder.

10. A hydraulic system comprising a hydraulic aggregate (60) for the generation of a fluid flow having a primary pressure (p1), wherein one or more hydraulically driven motors (62) can be coupled with the fluid flow generated by the hydraulic aggregate at a primary pressure and wherein one or more hydraulically driven motors (63) can be coupled with the fluid flow generated by the hydraulic aggregate at a secondary pressure (p2),

characterized in that a pressure transformer (61) is provided between the primary pressure (p1) and the secondary pressure (p2).

11. A hydraulic system comprising a hydraulic aggregate (70) for the generation of a pressure difference between a low pressure (p4) and an operational pressure (p3), wherein the low pressure is higher than a minimum pressure in the system, **characterized** in that a pressure transformer (72) is provided between the operational pressure (p3) and the low pressure (p4) for generating the low pressure.

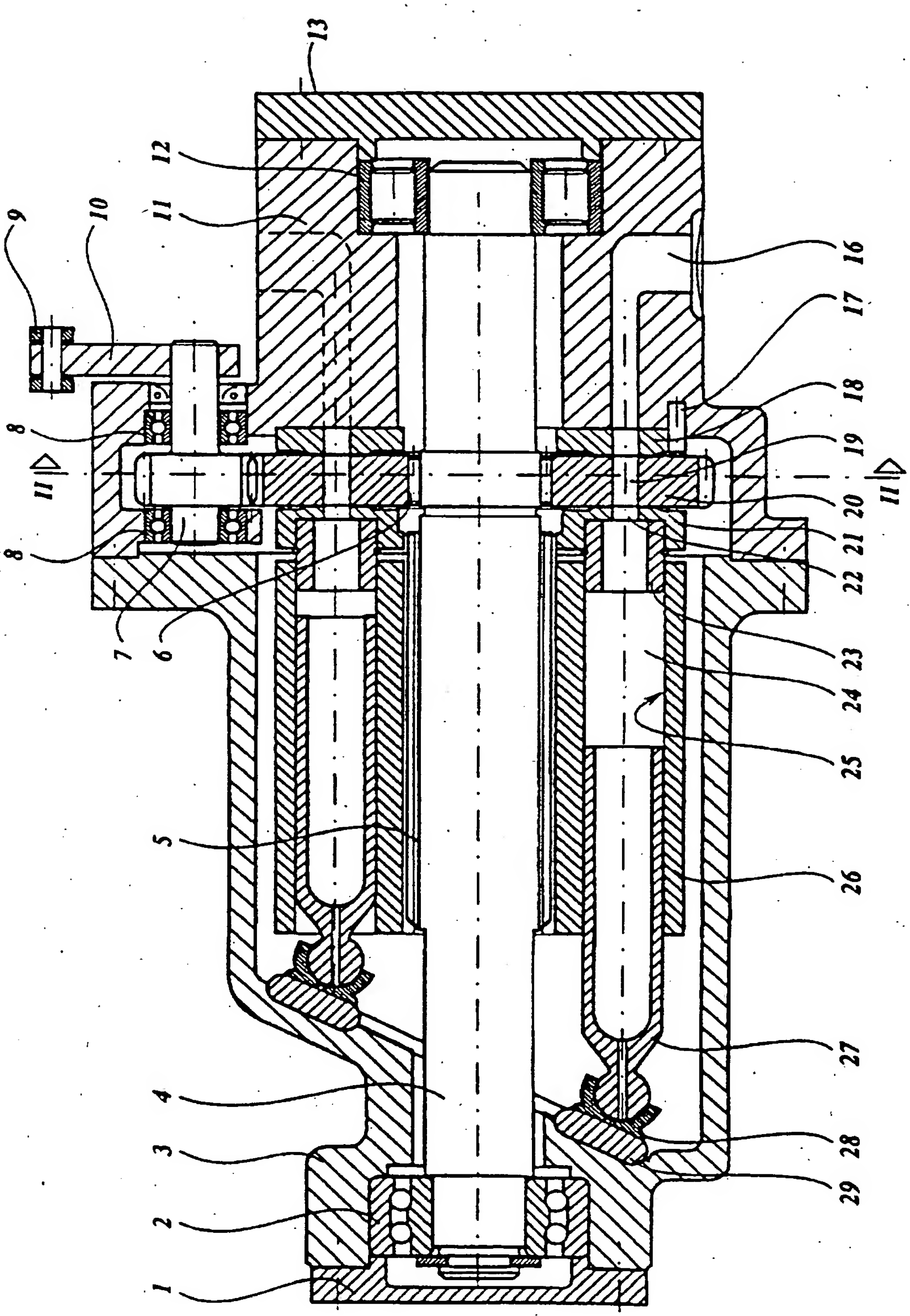
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Fig. 1

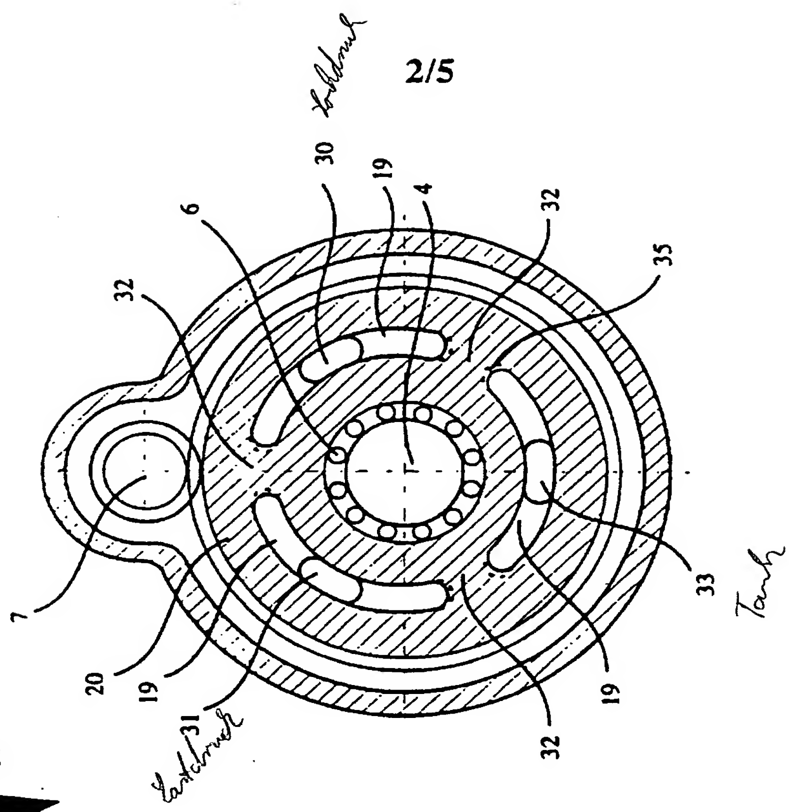

Fig. 2

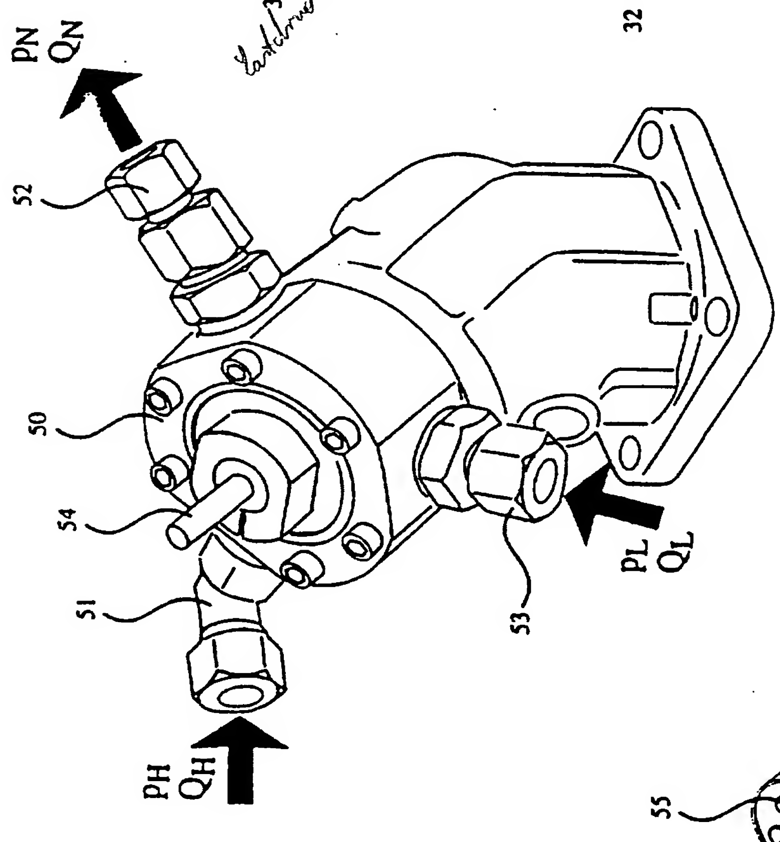

Fig. 11

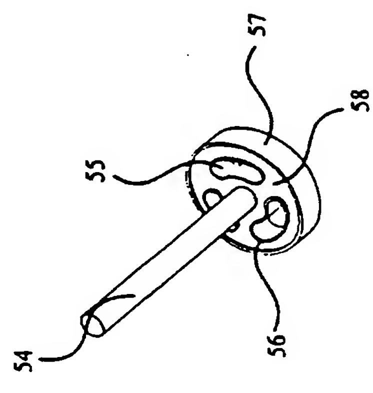

Fig. 12

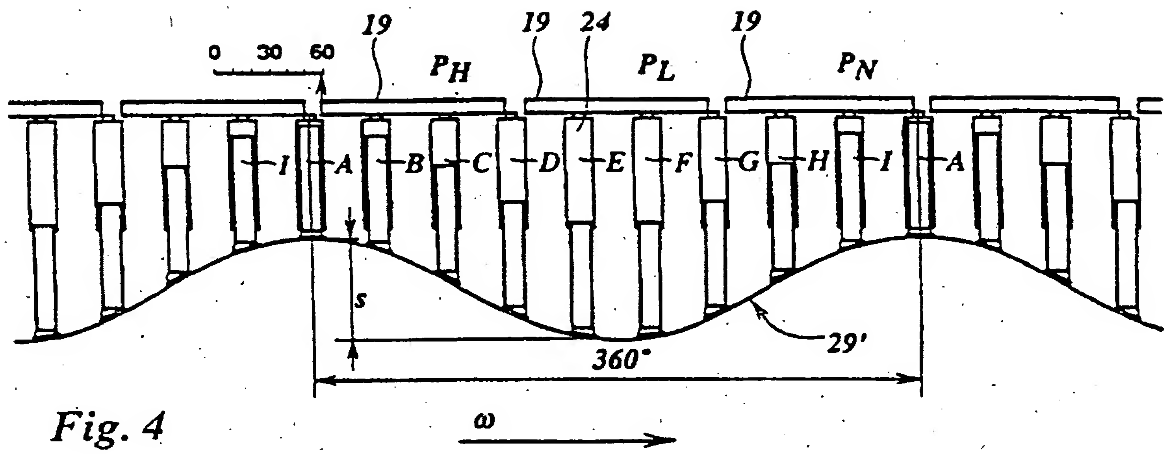

Fig. 4

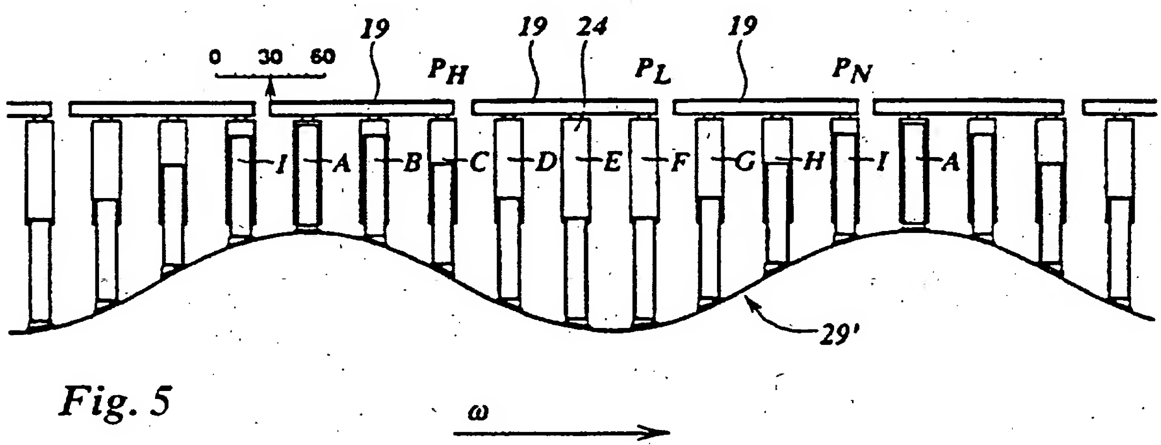

Fig. 5

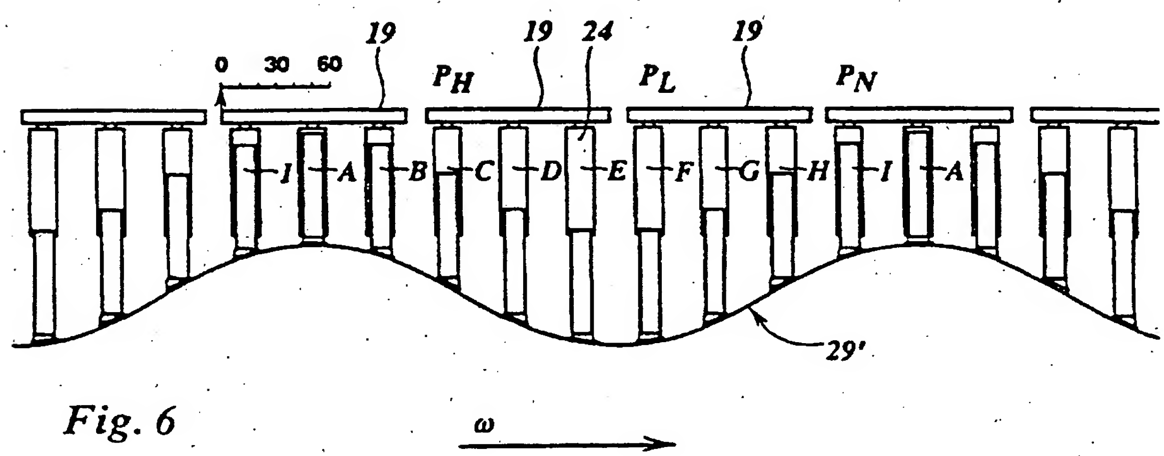

Fig. 6

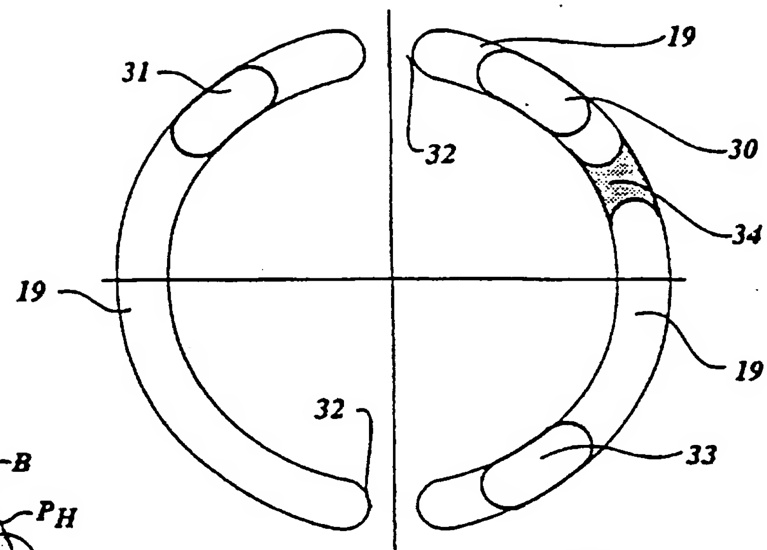

Fig. 3

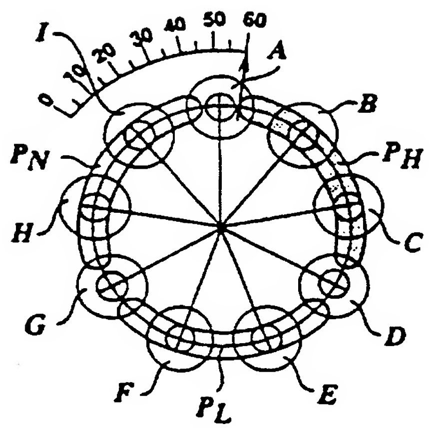

Fig. 7

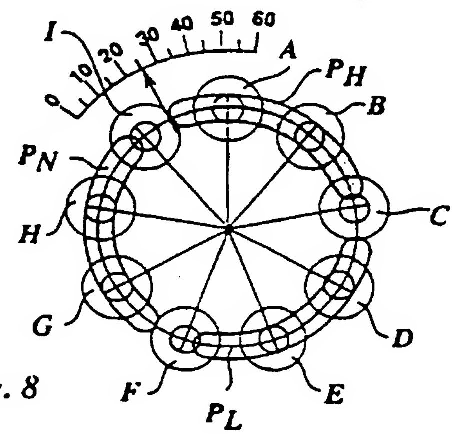

Fig. 8

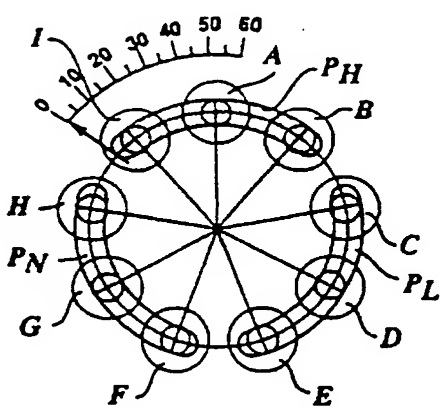

Fig. 9

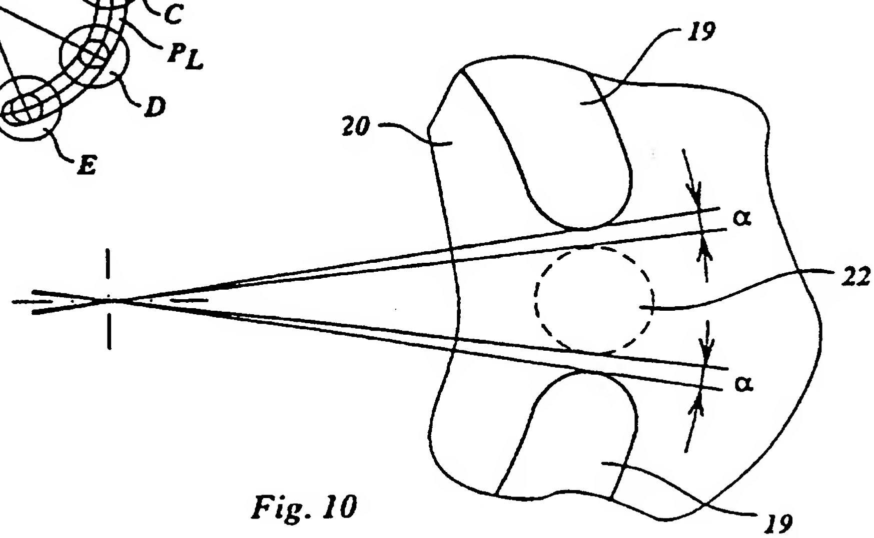

Fig. 10

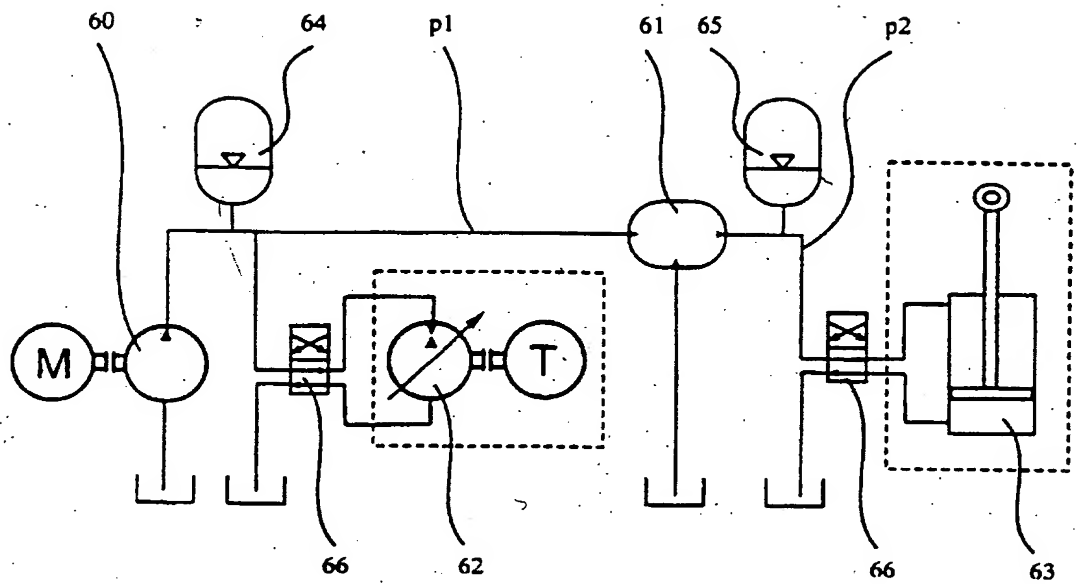

Fig. 13

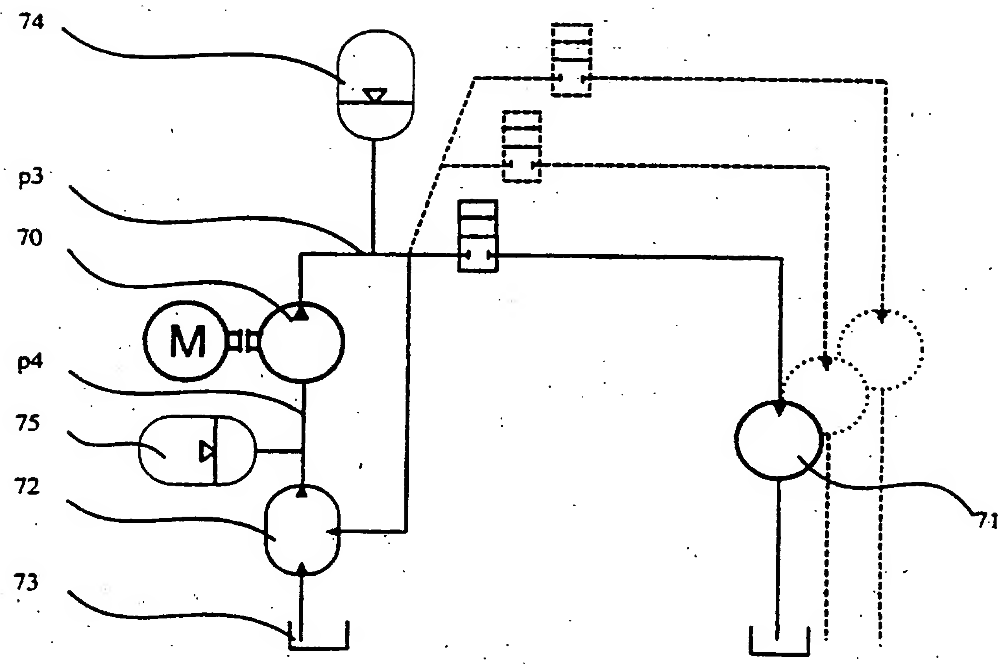

Fig. 14

INTERNATIONAL SEARCH REPORT

Inter. ..onal Application No
PCT/NL 97/00084

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F04B1/30 F04B1/20 F01B3/00 F15B3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F04B F03C F01B F15B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 077 746 A (REYNOLDS) 7 March 1978 see the whole document ---	1,2
X	US 3 627 451 A (KOUNS HERBERT H) 14 December 1971 see the whole document ---	1,2
A	US 5 035 170 A (STROZE MARK S ET AL) 30 July 1991 see the whole document ---	3,5,6
A	FR 1 303 925 A (NATIONAL UNION ELECTRIC CORPORATION) 18 January 1963 cited in the application see the whole document ---	3,4,8,9
A	US 3 223 047 A (TOY) 14 December 1965 see the whole document ---	3-6
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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Date of the actual completion of the international search	Date of mailing of the international search report
23 May 1997	16.06.97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Von Arx, H

Inter.   .onal Application No
PCT/NL 97/00084

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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PCT/NL 97/00084

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